# Fishing at Qal'at al-Bahrain, archipelago of Bahrain, from the Early Dilmun (2200 BC) to the Middle Islamic period (13-16th centuries AD)

by

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**Abstract**. – Excavations have taken place at the site of Qal'at al-Bahrain in Bahrain, Arabo-Persian Gulf, since the 1950's. They have revealed significant architectural remains and a rich assortment of material, including ceramics, metal objects, figurative representations, inscriptions, seals, and botanical and faunal remains, which include a large number of fish bones. Its exceptional stratigraphy, which extends from the Early Dilmun (ca. 2200 BC) to the Middle Islamic period (13-16th centuries AD), enables us to study and compare successive occupations. The results discussed here are based on the analysis of fish bones from the French and the previous Danish excavations. A total of 24,559 fish bones were studied, of which 10,515 can be identified as having precise stratigraphic dating. Four families dominate the assemblage: groupers (Serranidae), emperors (Lethrinidae), seabreams (Sparidae), and jacks (Carangidae). The taxonomic variety increases, however, to a total of 15 families during the Early Dilmun and Islamic period, and to 17 families during the Late Dilmun. The preliminary results discussed here provide evidence of the focus on marine resource exploitation in this region during these periods.

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**Résumé**. – La pêche à Qal'at al-Bahreïn, archipel de Bahreïn, du début du Dilmun (2200 avant JC) à la période islamique moyenne (13e-16e siècles de notre ère).

Fouillé depuis près de soixante années, le site archéologique de Qal'at al-Bahreïn, dans le golfe Arabo-Persique a fourni de nombreux vestiges architecturaux associés à un matériel archéologique diversifié (céramique, métal, représentations figurées, inscriptions, sceaux, macrorestes végétaux et fauniques, incluant un grand nombre de restes de poissons). La stratigraphie exceptionnelle, qui s'étend du Dilmoun Ancien (env. 2200 av. J-C.) jusqu'à la période islamique (13e-16e siècles ap. J-C.), permet l'étude comparative des occupations successives du site. Ici sont présentés les résultats de l'étude des restes osseux de poissons exhumés lors des fouilles françaises, complétés par les résultats obtenus lors des précédentes fouilles danoises. Sur plus de 24 559 os étudiés (dont 4 227 étudiés par la mission danoise), 10515 ont été déterminés. Quatre familles dominent le spectre de faune tout au long de l'occupation : les serranidés (mérous), les carangidés (carangues), les sparidés (daurades) et les léthrinidés (empereurs). La variété taxinomique peut cependant atteindre 15 familles au Dilmoun Ancien et à l'époque islamique et 17 familles au Dilmoun Récent. Les résultats préliminaires présentés ici enrichissent nos connaissances sur l'exploitation du milieu marin dans la région à ces époques.

**Key words**
Fish remains
Fishing
Bahrain
Archaeoichthyology
Dilmun period
Tylos period
Islamic period

Fishing in the Gulf has played an important role in the local economy since the first occupations. During the last twenty years, several studies on ichthyofaunal material from sites in the region (e.g. Von den Driesch and Manhart, 2000; Beech, 2005; Uerpmann and Uerpmann, 2005), as well as a synthesis (Beech, 2004), have been undertaken, which offer an overall vision of its ancient fishing. However, some sites with a strategic position in the Gulf, such as Qal'at al-Bahrain, have not been as intensively studied.

The first excavation at Qal'at al-Bahrain (archipelago of Bahrain, in the Arabo-Persian Gulf), in 1954, uncovered both outstanding stratigraphy and chronology. The presence of a rare mooring area (i.e. a channel through a coral reef) enabled populations to access and settle on the island, resulting in the establishment of a town from the Early Dilmun (ca. 2200-1750 BC), which continued through to the Islamic period (16th century). The numerous military (coastal fortress of the Sassanian period and impressive Islamic-Portuguese fort), political and religious (palace and temple from the Bronze and possibly Iron Age), and civil (series of domestic housing) architectures attest to the city economic strength during this period.

The present diachronic study of the fish bones complements earlier work by Uerpmann (1993), Uerpmann and Uerpmann (1994, 1997), Van Neer and Uerpmann (1994), essentially on early levels, and by Desse-Berset (1994, 1995); however, our approach aims to encompass a wider global vision of the insular territories occupation, from the Early Dilmun to the Islamic period.

## MATERIALS AND METHODS

The bones studied were discovered on the sea facing tell (or occupation mound) of Qal'at al-Bahrain (Fig. 1) during different excavation seasons (1989 to 1996 and 2000

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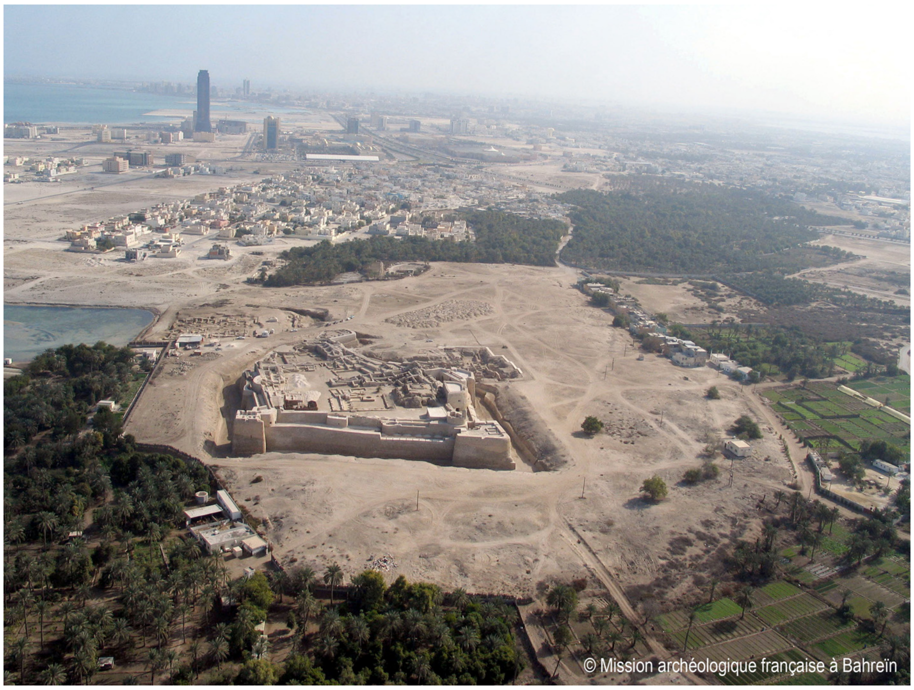

Figure 1. - Aerial view of Qal'at al-Bahrain (photo: French archeological mission).

to 2004). All the occupational phases of the site, from the Early Dilmun to the Islamic period, were represented in the material to varying degrees. However, the small proportion of elements for the Tylos period must be noted, as previous excavations poorly explored this occupation level.

The material was sampled by both archaeological structure and stratigraphic unit, which simplified matching it to an occupation period and allowed for a more diachronic study. As a general rule, the abundant and well-preserved bones were hand-collected from the trenches; however, systematic sieving of some of the sediments was required in some areas, and for all the Dilmun levels (Tab. I). For the most recent occupations, the Tylos and Islamic periods, sieving was only necessary for some stratigraphic units. This material, studied primarily for the Late Dilmun and the Islamic period, provided fish elements such as otoliths and scales not commonly found through hand-collecting. The sieving also yielded evidence for additional small fish taxa, such as clupeids (sardines) and siganids (rabbitfish), as well as for smaller specimens of taxa already represented by the hand-collected material.

Table I. - Percentages of sieved and handpicked materials for the Late Dilmun and Islamic Period. Number of identified remains by taxon and occupation period (NISP) = 13553.

| | Sieved | | Handpicked | |
|---|---|---|---|---|
| | NISP | % NISPR | NISP | % NISPR |
| Late Dilmun | 558 | 8.3 | 6200 | 91.7 |
| Islamic Period | 219 | 3.2 | 6576 | 96.8 |

Though in some areas, essentially those dated to the Middle Dilmun, heavy fragmentation of the material made identification impossible, in general the material was in an excellent state of preservation. This conservation and abundance resulted in remarkable anatomical diversity (i.e. vertebrae, cranial bones, otoliths, scales) within a wide faunal assemblage throughout each period; it also enabled the observation of traces, especially cut marks.

This faunal assemblage must be considered cautiously, however, as due to the lack of systematic sieving for each occupation level (bar the Tylos and Islamic periods), it provides us with a biased view of the fish consumed on the site, and prevents valid comparison between periods. In fact, the considerable biodiversity found in the Gulf waters is not well represented in the bone remains of Qal'at. This bias may be partly rectified by examining the sieved material, which offers a wide qualitative variety; though it does not allow us to quantify the small fish (identified only in a few samples) compared to larger species, whose bones are much more abundant.

Finally, some fish elements could not be determined at the species level because of a lack of comparable skeletons, or because of the great taxonomic diversity within a genus. For example, the choice to limit the identification of Serranidae to the *Epinephelus* genus is explained by the similarity of the species within the genus and the small variation of their biotope. However, we have concluded that specific identification in this case is not crucial to understand the subsistence economy and fishing methods of the population.

Table II. - Species list of the site of Qal'at al-Bahrain, indicating the number of remains by taxon and occupation period (NISP = 10516).

| Family | Species | Common name | Early Dilmun | | Middle Dilmun | Late Dilmun | Tylos Period | Islamic Period |
|---|---|---|---|---|---|---|---|---|
| | | | Danish excavations | French excavations | | | | |
| Carcharhinidae | *Carcharhinus* sp. | Shark | 17 | | 9 | 6 | | 2 |
| | *Rhizoprionodon* sp. | Shark | | | 3 | | | |
| Sphyrnidae | | Hammer shark | 9 | | | | | |
| Pristidae | | Sawfish | 1 | | | | | |
| Myliobatidae | *Aetobatus narinari* | Spotted eagle ray | | | 1 | 1 | | |
| | Unidentified Myliobatidae | | | | 12 | 1 | | |
| Rhynchobatidae | | Wedgefish | 2 | | | | | |
| Rhinobatidae | | Guitarfish | 27 | | | | | |
| Ariidae | *Netuma bilineata* | Bronze catfish | | 1 | | | 2 | 2 |
| | *Netuma thalassina* | Giant catfish | 17 | 1 | | 21 | | 3 |
| | *Netuma* sp. | | | | 1 | 8 | | 23 |
| Belonidae | *Tylosurus crocodilus* | Hound needlefish | | 4 | | | | 4 |
| | *Tylosurus choram* | Red Sea houndfish | | | | 1 | | |
| | *Tylosurus* sp. | | | | | 2 | | |
| | *Ablennes hians* | Flat needlefish | | | | | | 2 |
| | Unidentified Belonidae | | | | | | | 1 |
| Carangidae | *Alectis indica* | Indian threadfish | 1 | | 1 | | | |
| | *Atule mate* | Yellowtail scad | | | 1 | 1 | | |
| | *Alepes* sp. | | | | 4 | 2 | | 2 |
| | *Carangoides bajad* | Orangespotted trevally | | 15 | 22 | 248 | 6 | 9 |
| | *Carangoides chrysophrys* | Longnose trevally | 22 | 1 | 1 | 6 | | 2 |
| | *Carangoides malabaricus* | Malabar trevally | | | 2 | | | |
| | *Carangoides* sp. | | 24 | 4 | 11 | 32 | | 21 |
| | *Gnathanodon speciosus* | Golden trevally | 47 | 19 | 76 | 323 | 15 | 53 |
| | *Scomberoides commersonnianus* | Talang queenfish | | 8 | 1 | 93 | 3 | |
| | *Scomberoides* sp. | | 25 | | 3 | 23 | | 17 |
| | *Seriola dumerili* | Greater amberjack | 4 | 1 | | 6 | 1 | |
| | *Seriola* sp. | | | 4 | | 6 | | |
| | *Trachinotus* sp. | | 1 | | | | | |
| | Unidentified Carangidae | | 304 | 13 | 46 | 95 | 3 | 16 |
| Clupeidae | *Nematalosa nasus* | Bloch's gizzard shad | | | | | | 3 |
| | Unidentified Clupeidae | | | | | 5 | | 6 |
| Haemulidae | *Diagramma pictum* | Painted sweetlips | | | 2 | | | 4 |
| | *Plectorhinchus pictus* | Trout sweetlips | | | | 1 | | 7 |
| | *Plectorhinchus* sp. | | | | | 2 | | 8 |
| | *Pomadasys argenteus* | Silver grunt | | | | 4 | | |
| | *Pomadasys kaakan* | Javelin grunter | | | | 1 | | |
| | *Pomadasys stridens* | Striped piggy | | | | 2 | | |
| | *Pomadasys* sp. | | | | 1 | | | 1 |
| | Unidentified Haemulidae | | | | 1 | 1 | | 1 |
| Holocentridae | Unidentified Holocentridae | Squirrelfish | | | | 2 | | |
| Lethrinidae | *Lethrinus* spp. | Emperor | 888 | 78 | 1690 | 1212 | 43 | 436 |
| Lutjanidae | *Lutjanus malabaricus* | Malabar blood snapper | | | | | | 1 |
| | *Lutjanus* sp. | | | 2 | | | | 1 |
| | Unidentified Lutjanidae | | | | | | | 1 |
| Mugilidae | *Liza* sp. | Mullet | | | 3 | | | 1 |
| | *Valamugil* sp. | | | | 1 | | | 1 |
| | Unidentified Mugilidae | | | | | 2 | | 3 |

Table II. - Continued.

| Family | Species | Common name | Early Dilmun |  | Middle Dilmun | Late Dilmun | Tylos Period | Islamic Period |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Danish excavations | French excavations |  |  |  |  |
| Nemipteridae | Unidentified Nemipteridae | Threadfin bream |  |  |  | 1 |  |  |
| Scaridae | *Scarus ghobban* | Blue-barred parrotfish |  |  |  |  |  | 3 |
|  | *Scarus* sp. |  |  | 1 |  | 1 |  | 5 |
|  | Unidentified Scaridae |  |  |  |  |  |  | 2 |
| Scombridae | *Euthynnus/Thunnus* spp. |  | 5 |  | 2 |  | 1 |  |
|  | *Euthynnus affinis* | Kawakawa | 1 | 1 | 1 | 4 |  | 19 |
|  | *Rastrelliger kanagurta* | Indian mackerel |  |  |  |  |  | 1 |
|  | *Scomberomorus commerson* | Narrow-barred Spanish mackerel |  |  | 1 |  | 4 | 1 |
|  | *Scomberomorus* sp. |  | 2 |  | 1 |  |  | 1 |
|  | *Thunnus obesus* | Bigeye tuna |  |  |  | 3 |  | 3 |
|  | *Thunnus tonggol* | Longtail tuna |  |  |  |  |  | 3 |
|  | *Thunnus* sp. |  | 9 |  | 6 | 8 |  | 35 |
|  | Unidentified Scombridae |  |  | 1 |  | 2 | 2 | 7 |
| Serranidae | *Epinephelus* spp. | Grouper | 1041 | 134 | 78 | 466 | 31 | 477 |
| Siganidae | *Siganus* sp. | Rabbitfish |  |  | 15 | 106 |  | 48 |
| Sparidae | *Acanthopagrus bifasciatus* | Twobar seabream |  | 10 | 21 | 104 | 3 | 34 |
|  | *Acanthopagrus latus* | Yellowfin seabream |  |  |  | 2 |  |  |
|  | *Acanthopagrus* sp. |  | 37 |  | 23 | 21 |  | 38 |
|  | *Argyrops spinifer* | King soldier bream | 164 | 22 | 3 | 303 | 13 | 40 |
|  | *Cheimerius nufar* | Santer seabream |  | 1 |  | 1 |  | 2 |
|  | *Crenidens crenidens* | Karanteen seabream |  |  |  | 2 |  |  |
|  | *Rhabdosargus* sp. |  |  | 14 | 38 | 89 | 2 | 26 |
|  | *Rhabdosargus haffara* | Haffara seabream |  |  | 1 | 11 |  |  |
|  | *Rhabdosargus sarba* | Goldlined seabream | 63 | 2 |  | 2 |  |  |
|  | *Sparidentex hasta* | Sobaity seabream |  |  | 1 |  |  | 2 |
|  | Unidentified Sparidae |  | 186 | 9 | 34 | 314 | 1 | 46 |
| Sphyraenidae | *Sphyraena jello* | Pickhandle barracuda |  | 1 |  |  |  |  |
|  | *Sphyraena obtusata* | Obtuse barracuda |  |  | 2 | 7 | 1 |  |
|  | *Sphyraena* sp. |  | 2 | 1 | 3 | 36 |  | 1 |
| Total identified |  |  | 2899 | 348 |  |  |  |  |
|  |  |  | 3247 |  | 2122 | 3590 | 131 | 1425 |

The fish remains were identified using the reference collections of CEPAM[1] and MNHN[2]. The typical diversity of the region was well represented throughout the quantity of reference skeletons. Specimens of different sizes were available for each taxon, which enabled reconstructing the lengths and weights of some species. Regression equations were used for *Epinephelus* spp. (Desse and Desse-Berset, 2000) and *Lethrinus* spp. (Vorenger, unpubl. data). For the other families, a direct comparison with fish of known length was used.

Quantification was based on the number of identified specimens (NISP).

## RESULTS

By combining both the French and Danish data, 24,559 bones have been studied, out of which 10,515 were identified, representing an identification rate of 43%. This relatively high percentage is due to the good preservation of the material, which enabled some specific identification. In total, 22 families, 36 genera, and 37 species were identified. The results presented here are primarily based on the hand-

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[1] CEPAM (Cultures-Environnements. Préhistoire, Antiquité, Moyen Âge), UMR 7264, Pôle universitaire de Saint-Jean-d'Angély 3, 24 av. des Diables Bleus, F-06357 Nice CEDEX 4.

[2] MNHN (Muséum national d'Histoire naturelle), UMR 7209 Archéozoologie, Archéobotanique: sociétés, pratiques et environnements, 55 rue Buffon, F-75005 Paris.

Table III. - The fish families identified during the different occupation periods in Qal'at al-Bahraïn, expressed in number of identified remains (NR) and their percentages.

| | | Early Dilmun | | Middle Dilmun | | Late Dilmun | | Tylos | | Islamic Period | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NR | %NR | NR | %NR | NR | %NR | NR | %NR | NR | %NR |
| Chondrichthyes | Carcharhinidae | 17 | 0.5 | 12 | 0.2 | 6 | 0.09 | | | 2 | 0.14 |
| | Myliobatidae | | | 1 | 0.02 | 1 | 0.01 | | | | |
| | Pristidae | 1 | 0.03 | | | | | | | | |
| | Rhinobatidae | 27 | 0.8 | | | | | | | | |
| | Rhynchobatidae | 2 | 0.1 | | | | | | | | |
| | Sphyrnidae | 9 | 0.3 | | | | | | | | |
| | Unidentified Chondrichthyes | | | 12 | 0.2 | 1 | 0.01 | | | | |
| Teleostei | Ariidae | 19 | 0.6 | 1 | 0.02 | 29 | 0.43 | 2 | 1.53 | 28 | 1.96 |
| | Belonidae | 4 | 0.1 | | | 3 | 0.04 | | | 7 | 0.49 |
| | Carangidae | 494 | 15.2 | 168 | 2.8 | 835 | 12.35 | 28 | 21.37 | 120 | 8.42 |
| | Clupeidae | | | | | 5 | 0.07 | | | 9 | 0.63 |
| | Haemulidae | | | 4 | 0.1 | 11 | 0.16 | | | 21 | 1.47 |
| | Holocentridae | | | | | 2 | 0.03 | | | | |
| | Lethrinidae | 965 | 29.7 | 1690 | 27.7 | 1212 | 17.93 | 43 | 32.82 | 436 | 30.6 |
| | Lutjanidae | 1 | 0.03 | | | | | | | 3 | 0.21 |
| | Mugilidae | | | 4 | 0.1 | 2 | 0.03 | | | 5 | 0.35 |
| | Nemipteridae | | | | | 1 | 0.01 | | | | |
| | Scaridae | 1 | 0.03 | | | 1 | 0.01 | | | 10 | 0.7 |
| | Scombridae | 19 | 0.6 | 11 | 0.2 | 17 | 0.25 | 7 | 5.34 | 70 | 4.91 |
| | Serranidae | 1175 | 36.2 | 78 | 1.3 | 466 | 6.89 | 31 | 23.66 | 477 | 33.47 |
| | Siganidae | | | 15 | 0.2 | 106 | 1.57 | | | 48 | 3.37 |
| | Sparidae | 508 | 15.6 | 121 | 2 | 849 | 12.56 | 19 | 14.5 | 188 | 13.19 |
| | Sphyraenidae | 4 | 0.1 | 5 | 0.1 | 43 | 0.64 | 1 | 0.76 | 1 | 0.07 |
| Total | Unidentified Teleostei | 1429 | | 3971 | | 3161 | | 84 | | 5370 | |
| | Unidentified Chondrichthyes | 15 | | 3 | | 7 | | | | | |
| | Total identified | 3247 | | 2122 | | 3590 | | 131 | | 1425 | |
| | Total unidentified | 1444 | | 3974 | | 3168 | | 84 | | 5370 | |
| | Grand total | 4691 | | 6096 | | 6758 | | 215 | | 6795 | |

collected samples, and, to some extent, from the sieving by some excavation units.

The most numerous families represented across all periods are the Serranidae (*Epinephelus* spp., groupers), the Lethrinidae (*Lethrinus* spp., emperors), the Sparidae (eight species, seabreams), and the Carangidae (eight species, jacks). There were ten other families of teleosteans. Some cartilaginous fish were also found, and were represented by 91 vertebrae of Selachii (skates and sharks) (Tab. II).

For the Early Dilmun period (ca. 2200-1750 BC), we integrated the results from previous studies (Van Neer and Uerpmann, 1994) to create a corpus comprising 4,691 bones, of which 3,247 (69%) were identified. A total of 15 families, 19 genera, including 15 species, constitute the faunal assemblage, within which four families stand out (Tab. III): groupers (36%), emperors (30%), seabreams (15.5%), and jacks (15.2%). None of the 13 other families represent more than 1% of the identified remains.

In the Middle Dilmun (ca. 1500-1250 BC), the number of remains and taxonomic diversity exceeds that of the previous period, despite fragmentation. Out of 6,096 studied bones, 2,122 (35%) were identified, yielding an assemblage composed of 12 families, 25 genera, and 16 species (Tab. II). The heavily fragmented state of the material for this period is illustrated by the high number of unidentified remains. The four main families present during the previous period were also identified in this chronological phase, though in differing proportions: emperors dominate the assemblage with 79.5% of identified remains, followed by jacks (7.9%), seabreams (5.7%), and groupers, which dominated the assemblage during the previous period, with just 3.5%. The other eight families failed to contribute more than 1% to the identified remains.

The Late Dilmun phase (ca. 1000-450 BC) yielded a large quantity of material, with 6,758 studied bones, out of which 3,590 (53%) could be identified. This quantitative richness allowed for an assemblage of 17 families, 24 genera, and 23 species (Tab. II). As in the previous period, emperors dominate with 33.7% of identified remains, followed by seabreams (23.5%), jacks (23%), and groupers (13%). The 11 other families did not account for more than 1% of the identified remains. Finally, the relative importance of Siganidae, with 3% of the identified remains, and Sphyraenidae (1.2%), should also be noted.

The Tylos period (ca. 300 BC to 300 AD) represented the least quantitatively. Of the 215 bones studied, 131 remains (61%) were identified. These accounted for 7 families, 13 genera, and 9 species (Tab. II). Unfortunately, this small sample did not allow for the four main families to be clearly distinguished. However, emperors still dominate the assemblage with 33% of the identified remains, followed by groupers (24%), jacks (21%), and seabreams (14.5%). Tunas complete the assemblage, in higher proportions than in previous periods, with 5.5% of identified remains, followed in smaller proportions by catfish (1.5%) and barracudas (0.5%).

Finally, the Islamic period (14th-16th centuries AD) yielded 6,795 remains, of which 1,425 (21%) were identified. The assemblage consisted of 15 families, 29 genera, and 21 species (Tab. II). In order of importance, groupers dominate with 33.5% of the identified remains, followed by emperors (31%), seabreams (13), and jacks (8.5%). Eleven other families are included in the assemblage of this period, four accounting for more than 1%. Tunas and rabbitfish occupy an important place with 5% and 3% of the identified remains, catfish with 2%, and grunts with 1.5%. The other families did not contribute more than 1%.

## DISCUSSION

### Species spectra through time

As highlighted in previous studies, the recurrence of the same four families (i.e. emperors, groupers, jacks and seabreams), throughout each chronological period, was noted. Though their quantitative importance varies during each separate occupation, their ubiquitous presence is significant. As of today, as no other quantative data has been published, comparisons can only be made with the results from the Danish excavations.

In the Early Dilmun, the results achieved by Uerpmann (1993), Uerpmann and Uerpmann (1994, 1997), and Van Neer and Uerpmann (1994) highlighted the regular presence of groupers (36%), emperors (30%), seabreams (15%) and jacks (15%). Three other families complete this assemblage: catfish (0.6%), tuna (0.6%) and barracuda (0.1%). The ongoing study for this period confirms the preference for particular fish. Thus, in order of importance, groupers precede emperors, followed by jacks and seabreams, and finally tuna and catfish. Despite the small amounts of identified remains from the French excavations for this occupation period, percentages are equivalent, and contribute, to the data previously obtained by the Danish excavations. Furthermore, the taxonomic diversity has been significantly enhanced by the identification of particular species, such as *Carangoides bajad* (Forsskål, 1775), *Scomberoides commersonnianus* Lacepède, 1801, and *Acanthopagrus bifasciatus* (Forsskål, 1775).

For the following occupation period, the Middle Dilmun, we noticed a very clear dominance of emperors. The three other families (jacks, seabreams and groupers) were present but in much smaller proportions, and the remaining families even more discrete, with a rate below 1%, indicating that selective fishing was operated.

The Late Dilmun confirms the tendency of the previous period, with a preference for emperors and a loss of interest for groupers. Seabreams and jacks were well represented. Rabbitfish and barracudas were also noted. The other taxa present did not count for more than 1%.

This preference for emperor fish was also confirmed during the Tylos period. Quantitatively, these fish precede the groupers, jacks and seabreams, and catfish, tuna and mackerel start to gain in importance among the fished species.

During the Islamic period, groupers return as the most frequently consumed species, followed by emperors, seabreams, jacks, tunas and rabbitfish; catfish and grunts also occupied a significant place. It was noted that, during this period, a wider variety of fish were consumed to the determent of the four families which dominated the previous periods. This may reflect better fishing practices and/or a possible evolution of dietary preferences.

In parallel to this specific diversification observed in the Islamic period, the size of specimens from the four main families also changed. Analyses are currently being finalized; however, early indications suggest a clear difference in size from pre-Islamic and Islamic occupation periods among Lethrinidae and Epinephelinae (Fig. 2).

The size of lethrinids varies between 10 and 90 cm, although the average size is between 50 and 55 cm for the pre-Islamic periods. The curve alters for the following occupation with a majority of smaller sizes, less than 50 cm. The difference is less clear for the Epinephelinae, which have two fairly similar curves, though the sizes are smaller for the Islamic period, between 25 and 95 cm, as opposed to 35-125 cm for previous periods. This slight difference is also visible among carangids with *Gnathanodon speciosus* (Forsskål, 1775), ranging in size from 25 to 85 cm for the Islamic period, and 25 to 100 cm for the pre-Islamic periods. However, despite the presence of a large specimen, its average size was only between 65 and 70 cm for the entire occupation.

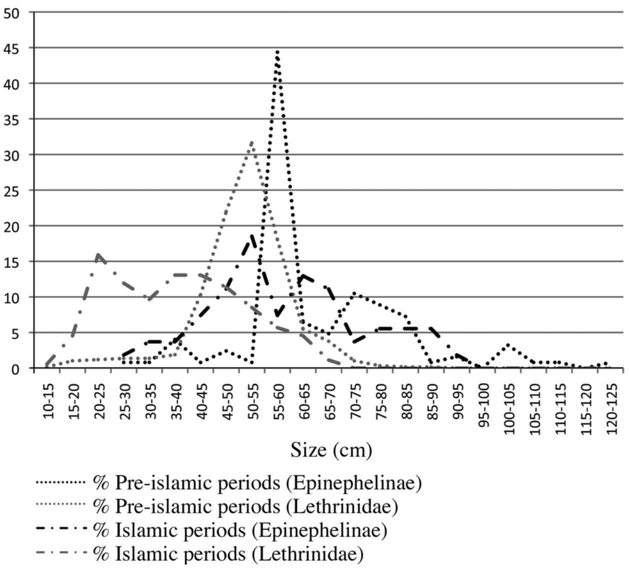

Figure 2. - Size (cm) of Epinephelinae and Lethrinidae for pre-Islamic and Islamic periods (NISP = 936).

For *Argyrops spinifer* (Forsskål, 1775), a frequently identified sparid, a significant difference exists between the two major periods. Indeed, for all the pre-Islamic occupations, almost 87% of the specimens, for which an estimate was possible, belong to specimens of more than 49 cm, in contrast to 57% for the subsequent occupation.

It can be clearly stated that an evolution of the species fished and consumed during the occupation of Qal’at al-Bahrain took place, with four families remaining constant within an increasingly broader faunal spectrum. Emperors appear to have been subject to intense fishing during the Middle Dilmun, though groupers, seabreams and emperors complete the assemblage. The diversity begins to increase during the Late Dilmun, with the slightly more regular occurrence of less fished species such as catfish, rabbitfish, tuna and barracuda.

This diversity in the faunal spectrum is accompanied by changes in the size of the fish caught, which is quite visible for the emperors, suggesting a change in fishing strategies through time.

## Biotope of identified fish

The eight species of identified Carangidae, *Alectis indica* (Rüppell, 1830), *Atule mate* (Cuvier, 1833), *Gnathanodon speciosus, Carangoides bajad, C. chrysophrys* (Cuvier, 1833), *C. malabaricus* (Bloch & Schneider, 1801), *Scomberoides commersonnianus, Seriola dumerili* (Risso, 1810), all evolve in the same biotope: around coastal coral reefs, generally in shallow water.

The main species identified for the Lethrinidae, *Lethrinus nebulosus* (Forsskål, 1775), lives in shallow water grass beds and mangroves, at least during the subadult stage. Based on their present day abundance in the Gulf and Bahrain, four other species of the same genus may be present on the site: *L. lentjan* (Lacepède, 1802), *L. mahsena* (Forsskål, 1775), *L. microdon* Valenciennes, 1830 and *L. borbonicus* Valenciennes, 1830; however, as with the Epinephelinae, identification for this family is limited to the genus.

Several species of Serranidae, or groupers, whose biotopes are similar (coral reefs), are present in the coastal waters of Bahrain. The decision was made, for now, to assign them the generic term *Epinephelus* spp., given their similar life conditions and the fragmented data on their specific ecology (Desse and Desse-Berset, 2000).

Eight species of Sparidae were present on the site: *Acanthopagrus bifasciatus*, *A. latus* (Houttuyn, 1782), *Argyrops spinifer*, *Cheimerius nufar* (Valenciennes, 1830), *Crenidens crenidens* (Forsskål, 1775), *Rhabdosargus haffara* (Forsskål, 1775), *R. sarba* (Forsskål, 1775) and *Sparidentex hasta* (Valenciennes, 1830). The first and last ones live in shallow depths (up to 60 m) and on sandy beds. *Argyrops spinifer* and *Cheimerius nufar* also live on the seabed but at a greater depth, between 150 and 300 m.

In the Scombridae family, five main species were identified: *Scomberomorus commerson* (Lacepède, 1800) and *Rastrelliger kanagurta* (Cuvier, 1816), which live in shallow waters (up to 70 m); and *Euthynnus affinis* (Cantor, 1849), *Thunnus obesus* (Lowe, 1839) and *T. tonggol* (Bleeker, 1851), deep open water predators (up to 250 m). For these species, seasonal inshore fishing as well as offshore fishing can be considered.

Nine other teleost families were found sporadically during the successive occupations: Ariidae, Sphyraenidae, Belonidae, Siganidae, Mugilidae, Haemulidae, Clupeidae, Lutjanidae and Scaridae. The sea catfish, *Netuma* spp., are mostly demersal and are often captured in the brackish lagoon waters of the coast. This is also the case for *Pomadasys argenteus* (Forsskål, 1775) and *P. kaakan* (Cuvier, 1830); while needlefish, (*Tylosurus* spp.) and barracuda (*Sphyraena* spp.,) are mostly pelagic fish that live near coral reefs. Others live in closer contact with the reef, such as *Siganus* spp., *Diagramma pictum* (Thunberg, 1792), *Plectorhinchus* spp., *Pomadasys stridens* (Forsskål, 1775) and *Scarus* spp. Finally, among the coastal fish living in schools in shallow depths, we find mullets (*Valamugil* spp., *Liza* spp.), and gizzard shad (*Nematalosa nasus* (Bloch, 1795)). Species belonging to the Lutjanidae are found in waters that are slightly deeper. Cartilaginous species are essentially found in the same biotopes, depending on their size.

To conclude, most species can be fished in shallow waters in coastal coral reefs (Belonidae, Carangidae, Serranidae, Sphyraenidae, Mugilidae, Haemulidae), mangroves or lagoons (Ariidae, Lethrinidae, Siganidae), or sandy beds (Sparidae).

Table IV. - Fishing techniques used to capture specific species in the Arabo-Persian Gulf (from Beech, 2004).

| Family | Species | Fishing techniques | | | | |
|---|---|---|---|---|---|---|
| | | Nets | Lines | "Gargour" | "Haddrah" | Gillnet |
| Carcharhinidae | *Carcharhinus* sp. | | | | × | × |
| | *Rhizoprionodon* sp. | | | | × | |
| Sphyrnidae | Unidentified | | | | × | |
| Pristidae | Unidentified | | | | × | |
| Myliobatidae | *Aetobatus narinari* | | | | × | |
| Rhynchobatidae | Unidentified | | | | × | |
| Rhinobatidae | Unidentified | | | | × | × |
| Ariidae | *Netuma bilineata* | × | | | × | |
| | *Netuma thalassina* | | | | × | |
| Belonidae | *Tylosurus crocodilus* | | | | × | × |
| | *Tylosurus choram* | | | | × | × |
| | *Ablennes hians* | | | | × | × |
| Carangidae | *Alectis indica* | | | | × | |
| | *Alepes mate* | | × | | × | × |
| | *Carangoides bajad* | | × | | × | × |
| | *Carangoides chrysophrys* | | | | × | |
| | *Carangoides malabaricus* | | | | × | × |
| | *Gnathanodon speciosus* | | | | × | × |
| | *Scomberoides commersonnianus* | | | | × | × |
| | *Seriola dumerili* | | | | × | × |
| | *Trachinotus* spp. | | | | × | × |
| Clupeidae | *Nematalosa nasus* | | | | × | × |
| Epinephelinae | *Epinephelus* spp. | | × | × | × | |
| Haemulidae | *Diagramma pictum* | | | | × | |
| | *Plectorhinchus pictus* | × | × | × | × | |
| | *Pomadasys kaakan* | | | | × | |
| | *Pomadasys stridens* | | | | × | |
| | *Pomadasys argenteus* | | | | × | |
| Lethrinidae | *Lethrinus* spp. | | × | × | × | × |
| Lutjanidae | *Lutjanus malabaricus* | | | × | × | × |
| | *Lutjanus* sp. | | | | × | |
| Mugilidae | *Liza* sp. | × | | | × | × |
| | *Valamugil* sp. | | | | × | |
| Scaridae | *Scarus ghobban* | | | × | × | × |
| | *Scarus* sp. | | | | × | |
| Scombridae | *Euthynnus affinis* | | | | × | × |
| | *Rastrelliger kanagurta* | | × | | × | × |
| | *Scomberomorus commerson* | | | | × | × |
| | *Scomberomorus* sp. | | | | × | |
| | *Thunnus obesus* | | | | × | × |
| | *Thunnus tonggol* | | | | × | × |
| Siganidae | *Siganus* spp. | | | × | × | × |
| Sparidae | *Acanthopagrus bifasciatus* | × | × | | × | × |
| | *Acanthopagrus latus* | | × | × | × | × |
| | *Argyrops spinifer* | | | | × | |
| | *Cheimerius nufar* | | | | × | |
| | *Crenidens crenidens* | × | | | × | |
| | *Rhabdosargus haffara* | | | | × | |
| | *Rhabdosargus sarba* | × | × | | × | × |
| | *Sparidentex hasta* | | | | × | |
| Sphyraenidae | *Sphyraena jello* | | | | × | × |
| | *Sphyraena obtusata* | | | | × | × |
| | *Sphyraena* sp. | × | × | | × | × |

## Fishing techniques in Bahrain

The presence of coastal species, as well as pelagic ones (e.g. tuna), shows that different fishing techniques must have been used. In fact, each species was probably captured with a specifically adapted technique, though all techniques (individually or combined) would have been just as efficient (Tab. IV).

Archeozoological analysis, as well as ethnoarcheological field work by Desse-Berset (1994, 1995), allows inferences concerning the possible techniques used by insular populations of Bahrain.

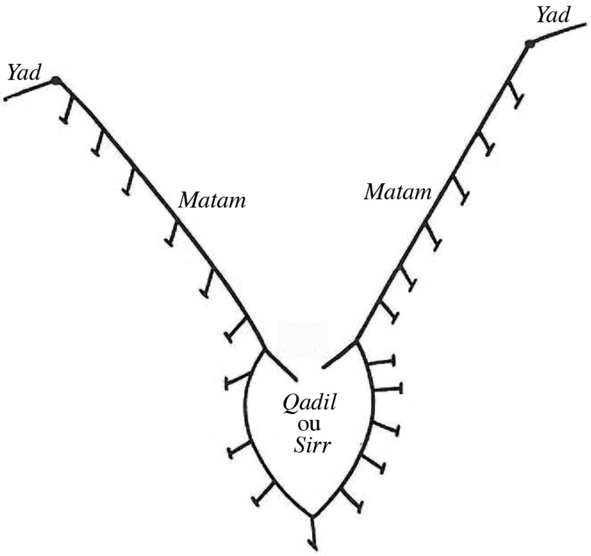

Figure 3. - Plan of a *haddrah* (from Al-Baharna, 1986).

## Current ethnographic data

### *Stationary fishing gear*

The marine environment around Qal'at al-Bahrain offers numerous advantages for exploitation, such as the shallow depth of the seabed (from 2 to 10 m, over 50 km), an advantageous tidal range (2.5 km), the presence of coral reefs, a variety of coastal ecosystems, and a mix of fresh and salt water. This environment is essential for the fishing of a large variety of species, and especially for the setting of weirs (*haddrah* locally). Theses traps are set up in the intertidal zone, on the reef flat, above the 2.5 km of uncovered foreshore. The *haddrah* itself consists of a fence (*mattam*) made of date palm fibres extending up 200 to 400 m. At the end is a pointed or circular chamber (*sirr* or *qadil*), with a diameter of around 4.5 m with two partially closed doors, leaving a passage of only a few centimetres. According to the environment and the currents, the shape of the *haddrah* can vary; however, the walls are systematically placed in the direction of the current, which is essential to the efficiency of the installation (Figs 3, 4). During high tide, the current brings the species along the fence of the trap and guides them to the point. Two doors at the entrance of the *sirr* allow them through to the main chamber. When the tide recedes, and the doors close, the species are trapped, but can survive as the water is still 60 to 90 cm deep, and never below 30 cm. The weir owners use then nets (*saliyah*) to capture their haul. If specimens are not picked up, they remain until the next tide (Desse-Berset, 1995).

In order to create and operate these weirs successfully, a sound knowledge of the surrounding environment, the seabed, the tides, the currents, and the prevailing winds, are required. It is a system so suited to this area, indeed all species living on the Gulf's seabed can be captured with *haddrah,* that it is still in use today along the coasts of Bahrain. Currently, siganids, carangids, belonids, sphyraenids and lutjanids are fished using this setup; shrimps are also being trapped this way (Al-Baharna, 1986). Indeed, up until the 1970s or 1980s, one *haddrah* could provide seven tons of fish and shrimps per year. As archaic installations, comparable to the contemporary ones, are mentioned from ancient texts such as Arrian or Diodorus of Sicily we can assume, roughly, how profitable they must have been.

### *Mobile fishing gear*

Fishermen use traps, traditionally made of different sized palms (*gargour*). These are big dome-shaped baskets, braided with 1 mm metal (previously, 1 mm-fibres were used). The bait used in the *gargour* is a green algae (*Enteromorpha* sp.) or fish powder. In the afternoon, the traps are placed in the subtidal zone, at depths between 4 and 12 m, and collected the following morning. The fish enter the trap through a funnel-shaped chimney, which makes exiting difficult for the small specimens, and impossible for larger ones.

Some species of Scombridae and Haemulidae (*Pomadasys commersonnii*) are currently fished with a hook and a line. These lines are generally made of an organic material and rarely survived, though hooks are often discovered in wood, bone, shell or metal in a variety of shapes.

Nets, like fishing lines, are often made of perishable material and are rarely preserved in an archeological context. The only elements we do find are terracotta weights; these are round clay objects with a central hole that allow them to be slipped onto the ground-rope of the net.

### *Archeological data*

It is highly probable that several of the techniques mentioned above were used during the different successive occupations of the site. The species richness attests to a highly developed fishing activity, which is predictable given Bahrain's insular position.

Fishing with lines and nets has been proven on site with the discovery of hooks and stone fishing weights, specifically during the Tylos period. Two anchor stones were also found, one dating from the Early Dilmun and the other from the Hellenistic period, probably used on fishing boats.

Archeological data collected in the Gulf region, especially in Kuwait and Oman, as well as the iconography of the Dilmun seals, give us an idea of early boat shapes. The oldest ones seem to have been made of tied reed or palm fibres covered with bitumen to seal them (Vosmer, 2000). The use of vessels made of assembled wooden planks was also, apparently, identified. It is possible that this type of vessel comprised most of the commercial maritime traffic between Sumer, Bahrain, Oman, and the Indus Valley. Several types of *dhows* are still frequently used in Bahrain for fishing and pearl collecting (Fig. 5): *Jaliboot*, *Sambook*, *Biteel*, *Baqarah*, *Boom*.

## CONCLUSION

The diachronic study of fish bones from the site of Qal'at al-Bahrain, from the Early Dilmun to the Islamic period, helps address part of the insular population economy in the main city of the island. We note the omnipresence of four main families throughout the occupation: emperors, groupers, seabreams, and jacks. These fish provided the majority of fish bones on the site but their proportions fluctuate within successive occupation periods. Other taxa complete the spectrum, but appear in smaller quantities, and may be a rather anecdotal complement linked purely to fishing opportunities. There is an increase in diversity over time,

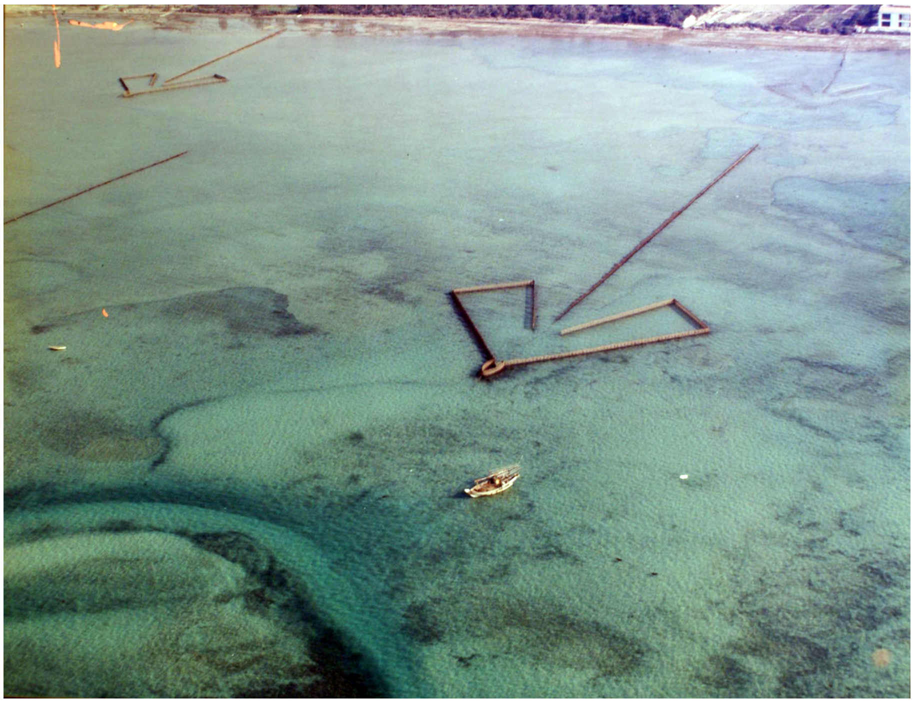

Figure 4. - Picture of *haddrah*, Bahrain (Bahrain National Museum, photo: J. Vorenger).

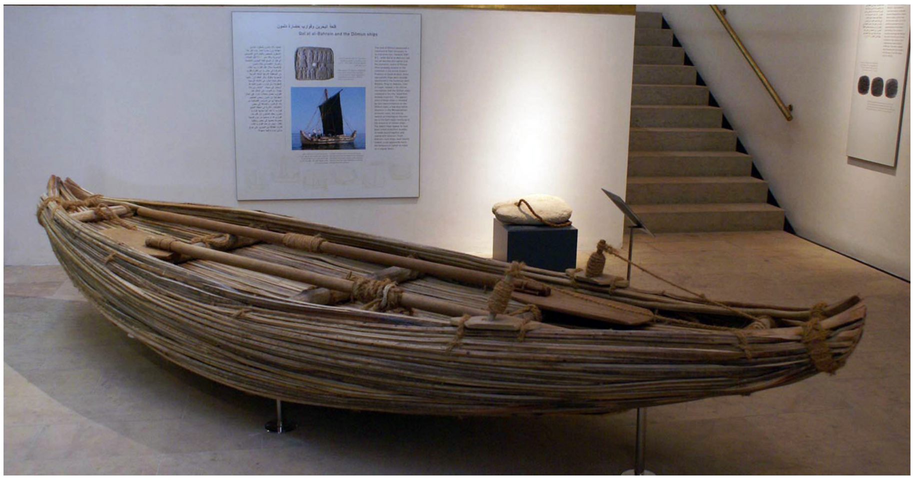

Figure 5. - Today, *jaliboots* are fishing boats (Bahrain National Museum, photo: J. Vorenger).

the assemblage of the Islamic period is significantly richer, showing an increased interest in other taxa.

The present results support and complete the previous Danish and French studies. Taking into account the sieved sediments allows us to further refine the acquired data, and to enrich the faunal assemblage in terms of identified taxa, as previous studies had only used hand-collected material. The current study, therefore, provides not only additional quantitative and qualitative data, but also gives a diachronic view of the exploitation of the sea by insular populations. An exploitation of mangroves or lagoons, coral reefs, and open water is documented showing that all adjacent aquatic environments were exploited, and an increasingly diverse range of fish was consumed. The paleoeconomy of successive cultures over the 4 millennium of occupation within this insular context relied on fishing.

It is conceivable that a big part of the abovementioned techniques, and particularly the traditional ones, were used by Bahrain populations over the centuries. Sadly, the only evidence we have of the skills used, or the knowledge required to implement them, by the Qal'at al-Bahrain fishermen are the excavated objects. And they provide only a brief glimpse of the ingenuity and expertise demonstrated by the Dilmun populations, which enabled them to master these elements and populate the islands.

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